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(71) Applicant: **ASAHI GLASS COMPANY LTD.**
1-2, Marunouchi 2-chome
Chiyoda-ku Tokyo 100(JP)

(72) Inventor: **Kuwata, Takeshi, AG TECHNOLOGY CO., LTD.**
1160, Matsubara, Hazawa-cho,
Kanagawa-ku
Yokohama-shi, Kanagawa-ken(JP)
Inventor: **Ikawa, Kohji, AG TECHNOLOGY CO., LTD.**
1160, Matsubara, Hazawa-cho,
Kanagawa-ku
Yokohama-shi, Kanagawa-ken(JP)
Inventor: **Asakawa, Tatsushi, ASAHI GLASS COMPANY LTD.**
Chuo Kenkyusho, 1150, Hazawa-cho,

Kanagawa-ku
Yokohama-shi, Kanagawa-ken(JP)
Inventor: **Hasebe, Hiroshi, ASAHI GLASS COMPANY LTD.**
Chuo Kenkyusho, 1150, Hazawa-cho,
Kanagawa-ku
Yokohama-shi, Kanagawa-ken(JP)
Inventor: **Nakazawa, Akira, AG TECHNOLOGY CO., LTD.**
1160 Matsubara, Hasawa-sho,
Kanagawa-ku
Yokohama-shi, Kanagawa-ken(JP)
Inventor: **Nagano, Hideyuki, ASAHI GLASS COMPANY LTD.**
Chuo Kenkyusho, 1150, Hazawa-cho,
Kanagawa-ku
Yokohama-shi, Kanagawa-ken(JP)
Inventor: **Ohnishi, Takanori, AG TECHNOLOGY CO., LTD.**
1160 Matsubara, Hazawa-cho,
Kanagawa-ku
Yokohama-shi, Kanagawa-ken(JP)

(74) Representative: **Wächtershäuser, Günter, Dr.**
Tal 29
W-8000 München 2 (DE)

(54) Image display device and a method of driving the same.

(57) An image display device having an electro-optical medium interposed between a pair of electrode substrates composing a matrix electrode, a driving means for driving the electro-optical medium by selectively applying a voltage on the matrix electrode and a reference voltage generator for supplying the driving means with a predetermined driving voltage, characterized by that a noise compensating means is interposed between the driving means and the reference voltage generator, the noise compensating means detecting a noise in a voltage supplied from the reference voltage generator to the electro-optical medium at a predetermined noise detecting position, forming a noise compensating voltage having a first polarity reverse to a second polarity of the noise by using the noise, and supplying the noise compensating voltage to the driving means.

device, and a column electrode waveform composed of an ON-voltage and an OFF-voltage, is controlled and applied on a column electrode. In Figures 10A and 10B, V_{adj} designates a control voltage which is supplied for controlling the liquid crystal display panel to be provided with a brightness which is easy to see.

However, even in a circuit inserted with the voltage followers after the divided resistors as shown in Figure 10B, the voltages V1 through V4 are not stable since they are superposed with various noises. Accordingly, there is a variation among root mean square voltages applied on the respective display dots, and a nonuniformity of display is caused.

It is an object of the present invention to provide an image display device having a uniform, with a small nonuniformity of display and easy-to-see image face, wherein a voltage distortion in a spike-like form is reduced by an effective feedback circuit.

According to a first aspect of the present invention, there is provided an image display device having an electro-optical medium interposed between a pair of electrode substrates composing a matrix electrode, a driving means for driving said electro-optical medium by selectively applying a voltage on said matrix electrode and a reference voltage generator for supplying said driving means with a predetermined driving voltage, characterized by that

a noise compensating means is interposed between the driving means and said reference voltage generator,

said noise compensating means detecting a noise in a voltage supplied from the reference voltage generator to the electro-optical medium at a predetermined noise detecting position, forming a noise-compensating voltage having a first polarity reverse to a second polarity of said noise by using the noise, and supplying said noise compensating voltage to the driving means.

According to a second aspect of the present invention, there is provided the image display device according to the first aspect, wherein the noise detecting position is at an input portion of the driving means for supplying the voltage.

According to a third aspect of the present invention, there is provided the image display device according to the first aspect, wherein a dummy electrode is provided on the electrode substrate and the noise detecting position is provided at said dummy electrode.

According to a fourth aspect of the present invention, there is provided the image display device according to the first aspect, wherein the noise compensating means is provided with an integrator, a change-over switch and an ON-OFF switch,

an output terminal of said change-over switch being connected to an input terminal of the driving means, a first one A of input terminals of the change-over switch being connected to an output terminal of the reference voltage generator, a second one B of the input terminals of the change-over switch being connected to an output terminal of the integrator,

a first input terminal of the integrator being connected to the predetermined noise detecting position through the ON-OFF switch, a second input terminal of the integrator being supplied with the reference voltage generated by the reference voltage generator as an offset voltage.

According to a fifth aspect of the present invention, there is provided the image display device according to the first aspect, wherein the driving means is supplied with an output of the reference voltage generator and a noise compensating voltage which is obtained by amplifying a difference between an input voltage at an input terminal of the driving means for a supply voltage and the reference voltage and by performing a negative feedback.

According to a sixth aspect of the present invention, there is provided the image display device according to the first aspect, wherein the noise compensating means is composed of a first differential amplifying means and a second differential amplifying means,

a positive input terminal of said first differential amplifying means being inputted with an output of the reference voltage generator, an output terminal thereof being connected to an input terminal of the driving means for a supply voltage, a negative input terminal thereof being inputted with an output of said second differential amplifying means whereby a difference between the reference voltage and a voltage at the input terminal of the driving means for the supply voltage is amplified.

According to a seventh aspect of the present invention, there is provided the image display device according to the first aspect, wherein the noise compensating means is composed of a delay means, an inverting amplifier and a change-over switch,

an output terminal of said change-over switch being connected to an input terminal of the driving means, a first one A of input switching terminals of said change-over switch being connected to an output terminal of the reference voltage generator, a second one B of the input switching terminals of the change-over switch being connected to the output terminal of the reference voltage generator through said delay

Figures 12A through 12C are diagrams of driving waveforms which are actually applied on a liquid crystal panel when the display in Figure 11B is performed;

Figures 13A through 13C are diagrams of driving waveforms which are actually applied on a liquid crystal panel when the display in Figure 11B is performed;

Figure 14 is a conceptive diagram for explaining a mechanism of generating a spike-like voltage distortion in a non-selecting level of a row electrode waveform; and

Figure 15 is a diagram showing a delay means.

In this invention, as a specific example of a reference voltage generator for outputting a reference voltage employed in driving a matrix-type display body, with respect to the above-mentioned V0 and V5, they are supplied directly from a power source or by emitter followers in use of transistors, and with respect to V1 through V4, they are supplied from the resistor-dividing of the power source. A noise compensating means is connected to the output side of the reference voltage generator. As the reference voltage, a selecting voltage, a non-selecting voltage, an ON-voltage, an OFF-voltage or the like is pointed out. It is necessary to connect the noise compensating means to an output of at least one of those reference voltages.

Explanation will be given to the operation of this invention concerning the cause of a noise and compensating the noise as follows.

First, explanation will be given to an example of the cause of a noise, in case of a liquid crystal matrix display element as follows.

A liquid crystal panel is constructed by interposing a dielectric body called a liquid crystal between transference electrodes, which is a capacitive load in view of a driving side thereof. Furthermore, a resistance value of the transference electrodes is not zero and is provided with a limited value. Therefore, even if an ideal waveform is applied thereon from a driver IC, the waveform is considerably distorted inside of the liquid crystal panel, thereby causing a nonuniformity of display. An example of the nonuniformity of the display will be explained by using Figures 11A and 11B, Figures 12A through 12C, Figures 13A through 13C and Figure 14. In this display, a so-called positive display wherein the more the root mean square voltage applied on a dot, the darker the dot.

When the display shown in Figure 11A is to be performed, actually, the nonuniformity of display as in Figure 11B is generated. The voltage waveform at dot portions of the row electrode C2 in a display area is shown in Figure 12A, the voltage waveform at the dot portions of the column electrodes S1 through S6, Figure 12B, and the voltage waveform applied on dots at the intersection points of the row electrode C2 and the column electrodes S1 through S6, Figure 12C. As shown in Figure 12A, spike-like voltage distortions are generated at the non-selecting voltage level of the row electrode waveform. Accordingly, as shown in Figure 12C, distortions of the waveform at non-selecting time, is generated.

The voltage waveform at the dot portions of the row electrode C2 is shown in Figure 13A, the voltage waveform at dot portions of the column electrode S7, in Figure 13B and the waveform applied on a dot at the intersection point of the row electrode C2 and the column electrode S7, in Figure 13C. As shown in Figure 13A, spike-like voltage distortions are generated at the non-selecting voltage level of the row electrode waveform. Accordingly, distortions are generated in the waveform at the non-selecting time as shown in Figure 13C.

As is simply understood by comparing Figure 12C with Figure 13C, in the waveform of Figure 12C, a root mean square value is smaller than that of an ideal waveform, and in the waveform of Figure 13C, the root mean square value is larger than that of the ideal waveform. Accordingly, in the actual display, the nonuniformity of display is generated as shown in Figure 11B.

Explanation will be given to a mechanism wherein the spike-like voltage distortion is generated in the non-selecting voltage level of the row electrode waveform by Figure 14. When the display shown in Figure 11A is to be performed, since the column electrode waveform applied to the column electrode 40 is in a rectangular waveform 37 as shown in Figure 14, this is differentiated by a capacitance C of the liquid crystal and a resistance value R of the row electrode 39, and the waveform 38 is superposed on the non-selecting level of the row voltage waveform. This waveform 38 can be detected at a supply voltage input terminal. However, the amplitude of the detected waveform is attenuated by the influences of the resistance of the electrode and an output impedance of a driver IC, compared with that of a waveform of a voltage actually applied on the liquid crystal. Therefore, the spike-like voltage distortion is generated on the non-selecting voltage level of the row electrode waveform.

This invention can reduce the nonuniformity of display by an original construction wherein a voltage distortion of a driving waveform generated inside of a panel in figures or letters which an image display device displays, is detected by at least one of a selecting voltage supplied to a driver IC, a non-selecting voltage, an ON-voltage and an OFF-voltage, the noise is converted into a noise compensating voltage

Next, for a time t_3 (reset period), the discharge switch 6 is closed and the integrator 30 is reset to an initial state thereof. In this occasion, the ON - OFF switch 4 may remain open and the change - over switch 3 may be switched to either one of A and B. The above sequence is summarized in Table 1.

Table 1

	t_1	t_2	t_3
3	A	B	A or B
4	Closed	Open	Open
6	Open	Open	Closed
t_1 : Noise sampling period t_2 : Hold period t_3 : Reset period 3: Change - over switch 4: ON - OFF switch 6: Discharge switch			

Figure 2D designates a voltage waveform at the non-selecting voltage input terminal 10 when the change-over switch 3 is connected to B during time periods of t_2 and t_3 . In this way, by applying the noise voltage to the driver IC9 by the feedback control, the spike-like noise is removed and the driving voltage which is stabilized on an average is supplied thereto.

When two of the circuits are formed to correct distortions of two non-selecting voltages, they achieve the effect of correction and reduction of the nonuniformity of display is observed. When one of the circuit corresponds to one of the two non-selecting voltages, almost the same effect is achieved.

In a more preferable driving method of this invention, a standby period t_4 is provided after the reset period t_3 , and a sequence composed of the noise sampling period, the hold period, the reset period and the standby period is iterated. In the standby period, the change-over switch 3 is connected to the terminal A. Furthermore, it is preferable that the ON - OFF switch 4 remains open. In this case, the discharge switch 6 may be open or closed.

By providing such a standby period, even when the frame frequency varies according to the kind of the display module, only the value of t_4 is changed to cope with it. That is, even when the frame frequency is changed, the noise compensating effect does not vary and a stabilized noise compensating effect can be provided.

Furthermore, a buffer amplifier may be interposed between the noise compensating means and the driving means according to the necessity. In this way, even when the capacity of the liquid crystal varies considerably, the compensating means sufficiently works.

Figure 3 shows a circuit construction of another embodiment of a liquid crystal display device of this invention employing a similar circuit construction. The output side of the driver IC 9 is connected to terminals of respective row electrodes of a liquid crystal panel 11, whereas the output side of a driver IC 12 for driving column electrodes is connected to terminals of respective column electrodes of the liquid crystal panel 11. The negative input terminal of the operational amplifier 5 in the integrator 30 is connected to a dummy electrode of a liquid crystal panel for detecting the spike-noise through a buffer amplifier 14 and the ON - OFF switch 4.

The circuit of this example differs from the embodiment in Figure 1 in the detecting method (detecting position) of the spike-like noise and the other construction and operation are the same with those in the embodiment of Figure 1. Accordingly, the same notation is attached to the same portion with that in Figure 1 and the explanation of operation is omitted. Furthermore, the buffer amplifier 14 may be omitted.

EXAMPLE 2

Figure 4 shows a second example of a portion of the circuit supplying the reference voltage to the driving means in the image display device of this invention. A reference numeral 61 designates divided resistors for generating one of two non-selecting voltages, which is a reference voltage generator. A numeral 66 designates a noise compensating means in this invention, and 64, a driver IC (driving means). The noise compensating means 66 is interposed between the reference voltage generator 61 and a driver

employed as the inverting amplifier 75. The position of the delay means 74 and the inverting amplifier 75 may be interchanged in the Figure.

Explanation will be given to the operation of the circuit of this Example as follows.

When the liquid crystal panel is in the display pattern as shown in Figures 11A, the column electrode waveform is as shown in Figure 6A. In this occasion, a spike-like voltage distortion (noise) as shown in Figure 6B is generated at the input terminal 76 for the non-selecting voltage of the driver IC 77.

When the change-over switch 73 of Figure 5 is connected to the switching terminal A, this voltage distortion is transmitted to the output of the operational amplifier 72, which is delayed by the delay mean 74 by a time t and amplified by the inverting amplifier 75. Accordingly, a voltage at the switching terminal B of the change-over switch 73 is deviated from the reference voltage as shown in Figure 6C.

Therefore, when a time t_1 which is shorter than the time t , has elapsed, by connecting the change-over switch 73 to B, a waveform shown in Figure 6D is observed at the input terminal 76 of the driver IC77 as a deviation of the reference voltage.

In the operation of the change-over switch 73, as shown in Figure 6E, the change-over switch 73 is connected to the switching terminal A during the starting time t_1 (reference voltage supply period, $t_1 \leq t$) in a cycle of a single row electrode selecting time, and to the switching terminal B during a residual time (noise correcting period) thereof. In this way, during the reference voltage supply period, the reference voltage outputted from the reference voltage generator superposed with the noise is applied to the input terminal 76 of the driver IC 77, and during the noise correcting period, a voltage wherein the reference voltages superposed with a voltage provided with a phase reverse to that in the reference voltage supply period, is supplied thereto.

As stated above (refer to Figure 14), the spike-like voltage distortion is attenuated compared with a wave height value thereof inside of the liquid crystal panel when it is detected by the delay means 74. Therefore, an amplification is performed in the amplifier 75 to correct the attenuated value. In this example, the delay means 74 is provided with 6 bits as the bit number in case of a digital system and the sampling frequency is 10 MHz. The delay time t depends on the capacity of the liquid crystal panel. In this example, the delay time is set to be 10 μ sec.

When two of the circuits are formed for correcting the distortions of two non-selecting voltages, they are effective in the correction of the voltage distortion and the reduction of the nonuniformity of display is observed. When one of the circuits is employed for one of the two non-selecting voltages, almost the same effect is achieved.

As stated above, the reduction of the nonuniformity of display is made possible in this invention, by canceling the voltage distortion which is superposed on the reference voltage supplied to the driver IC which is the driving means, by the effective feedback circuit. Furthermore, since the circuit construction is simple, the invention is provided with an advantage of realizing the circuit at a low cost.

In this specification, explanation has been given to the present invention with the example of a liquid crystal display device. However, this invention is applicable to various image display devices such as an electroluminescent display, a plasma display or the like.

Claims

1. An image display device having an electro-optical medium interposed between a pair of electrode substrates composing a matrix electrode, a driving means for driving said electro-optical medium by selectively applying a voltage on said matrix electrode and a reference voltage generator for supplying said driving means with a predetermined driving voltage, characterized by that

a noise compensating means is interposed between the driving means and said reference voltage generator,

said noise compensating means detecting a noise in a voltage supplied from the reference voltage generator to the electro-optical medium at a predetermined noise detecting position, forming a noise compensating voltage having a first polarity reverse to a second polarity of said noise by using the noise, and supplying said noise compensating voltage to the driving means.

2. The image display device according to Claim 1, wherein the noise detecting position is at an input portion of the driving means for supplying the voltage.

3. The image display device according to Claim 1, wherein a dummy electrode is provided on the electrode substrate and the noise detecting position is provided at said dummy electrode.

FIGURE 1

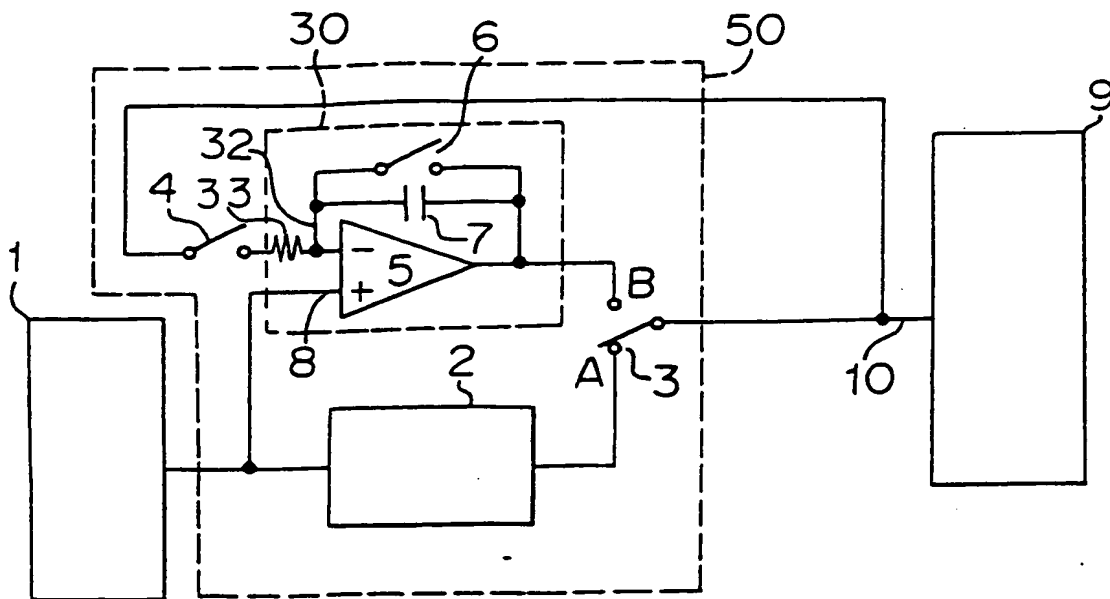


FIGURE 2A

FIGURE 2B

FIGURE 2C

FIGURE 2D

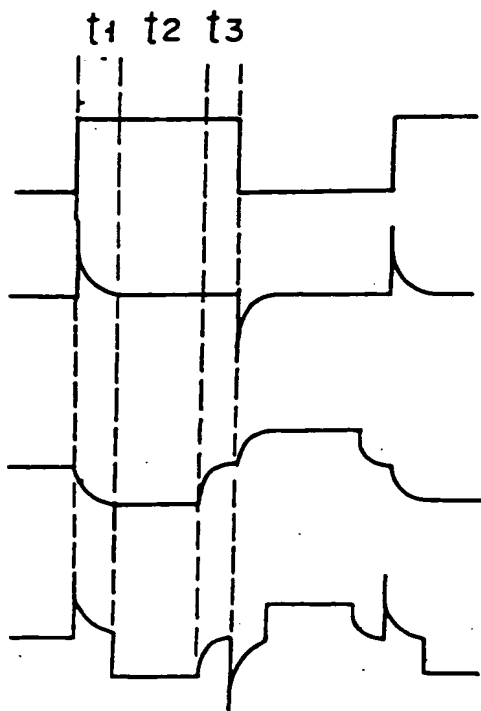


FIGURE 3

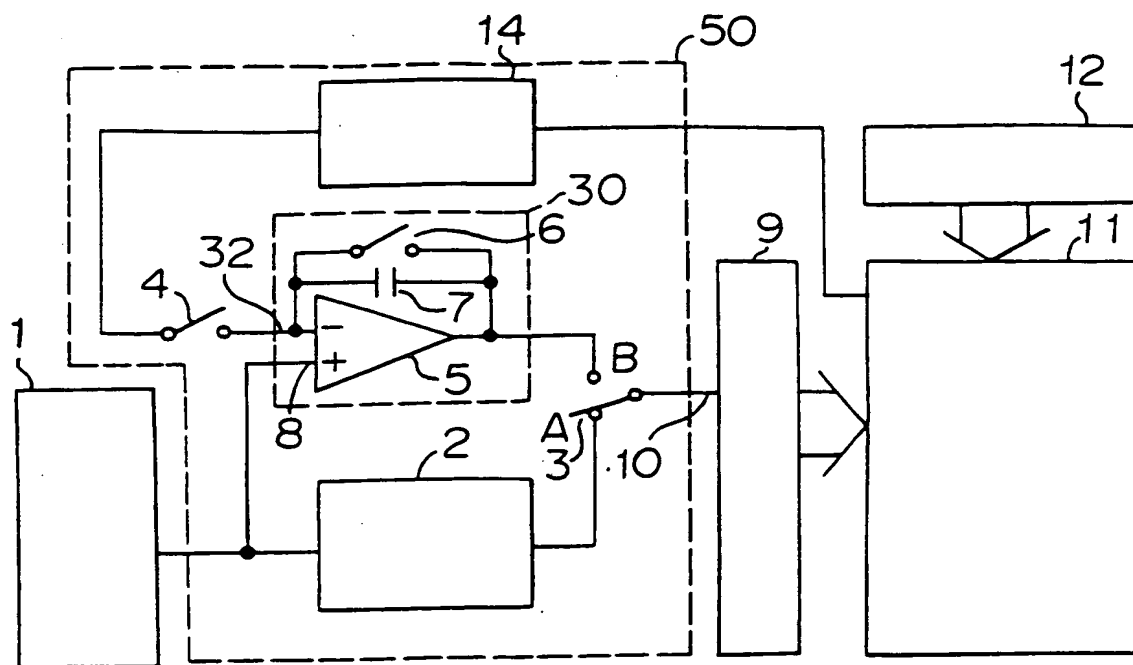


FIGURE 4

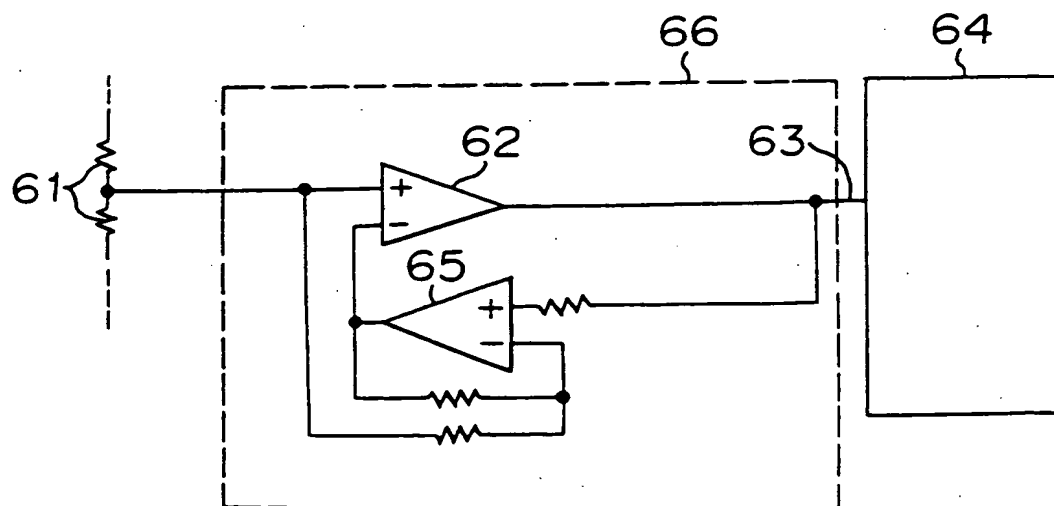
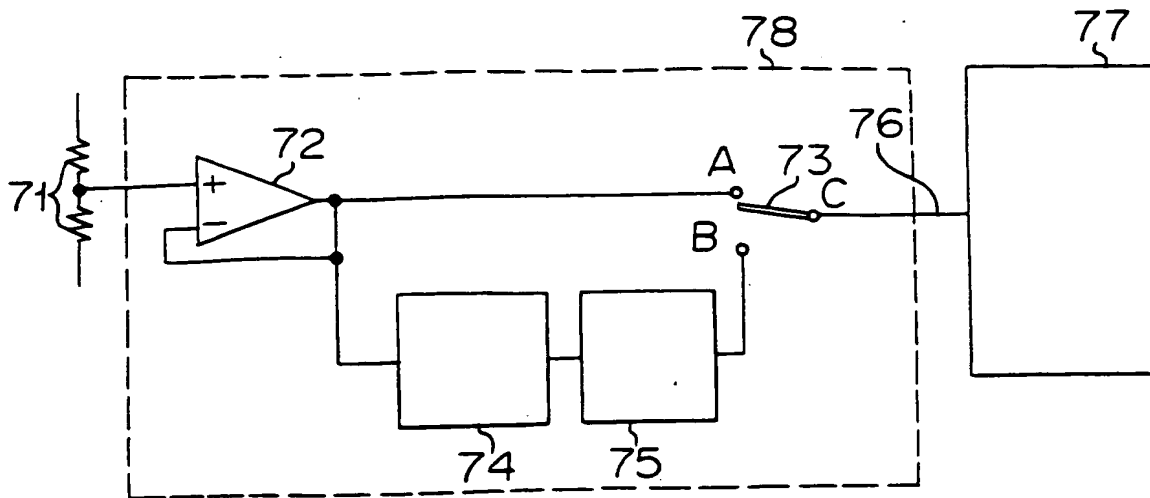


FIGURE 5



FIGURE

6 A



FIGURE

6 B



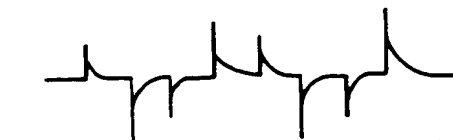
FIGURE

6 C



FIGURE

6 D



FIGURE

6 E



FIGURE 7

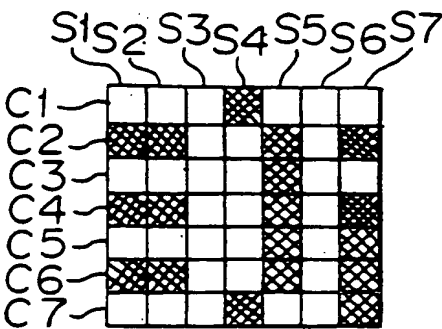
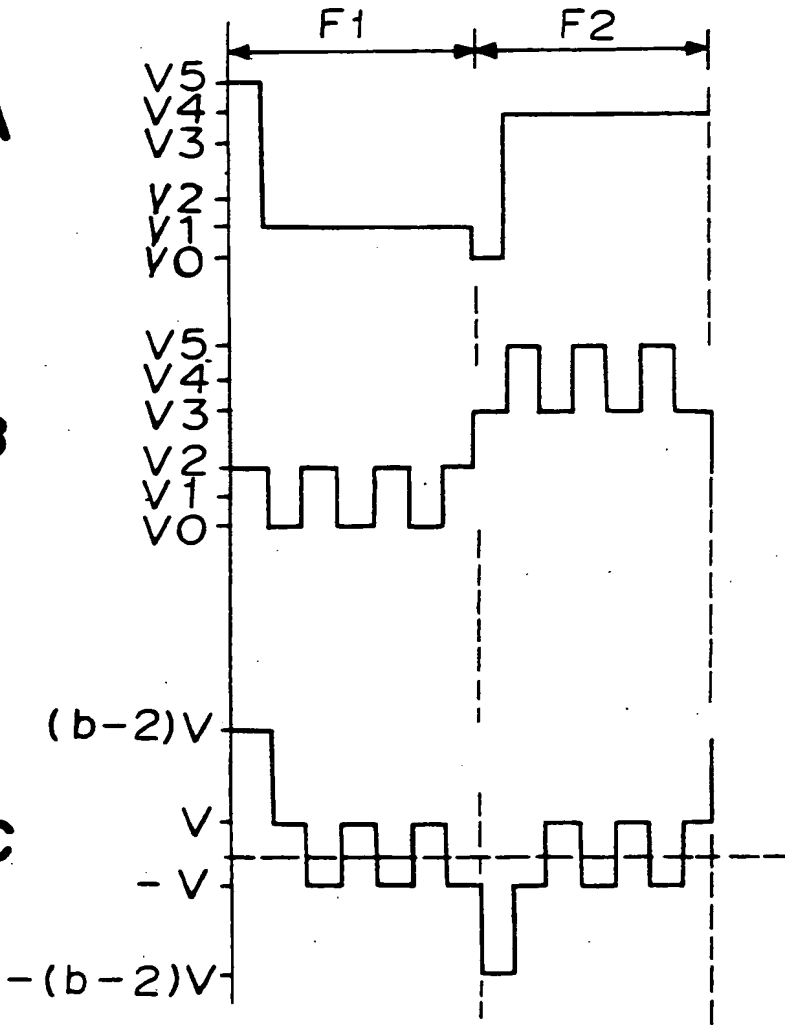


FIGURE 8 A

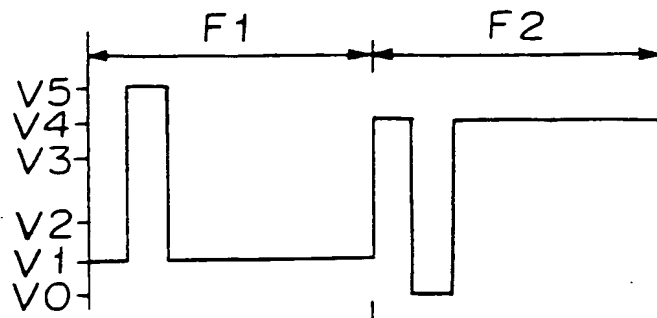
FIGURE 8 B

FIGURE 8 C



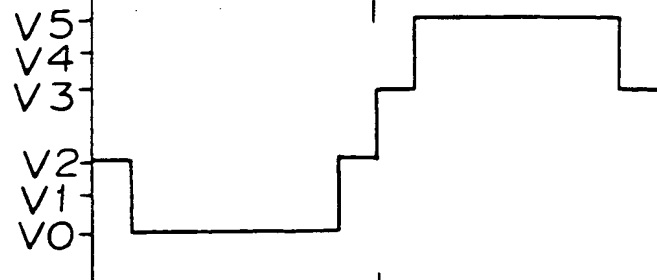
FIGURE

9A



FIGURE

9B



FIGURE

9C

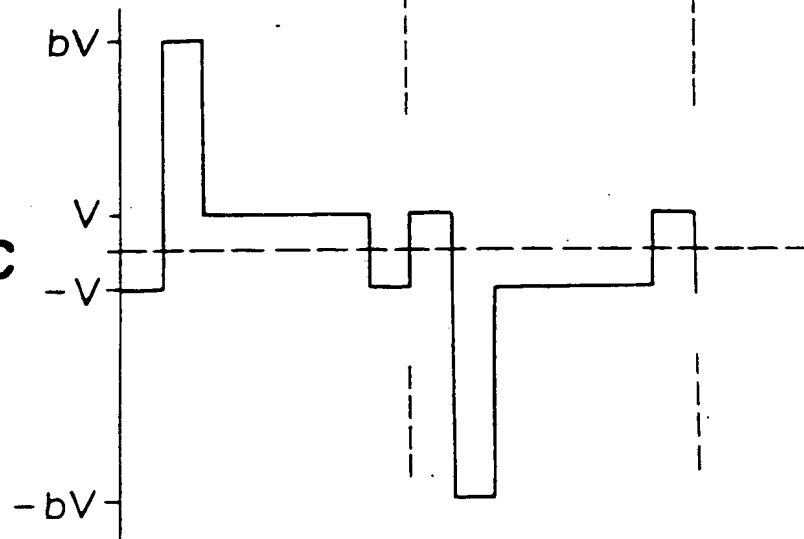


FIGURE 10A

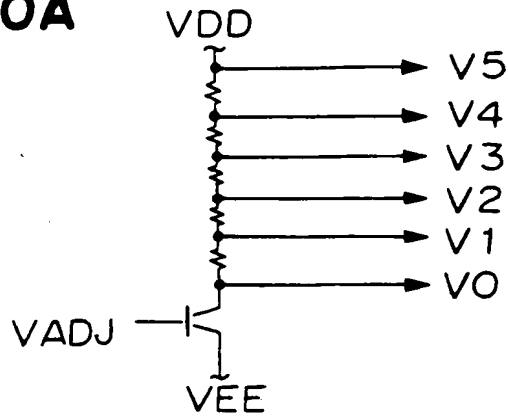


FIGURE 10B

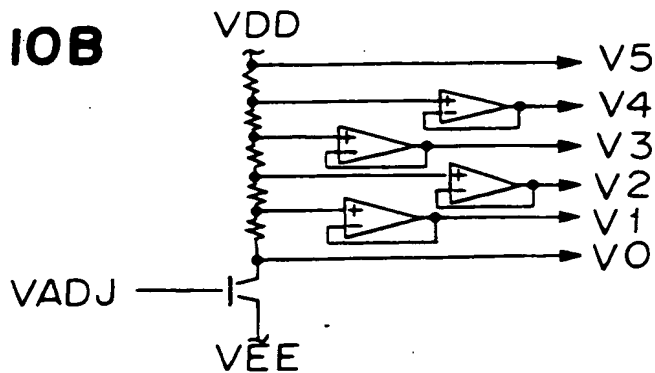


FIGURE 11A

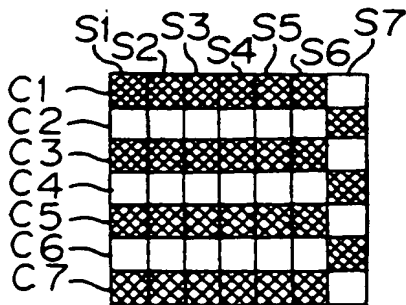
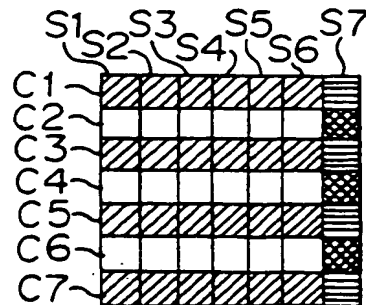


FIGURE 11B



BRIGHT > > > > > DARK

FIGURE 12A

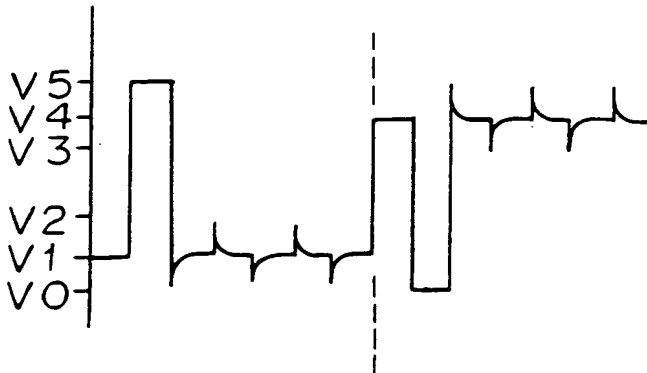


FIGURE 12B

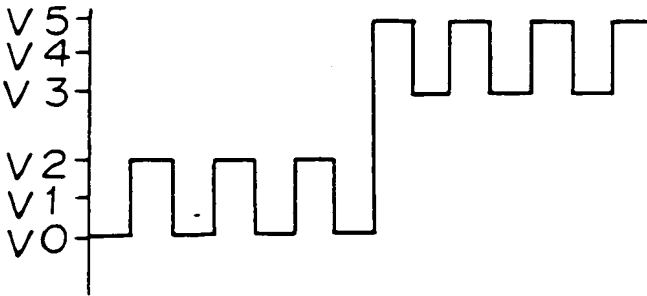


FIGURE 12C

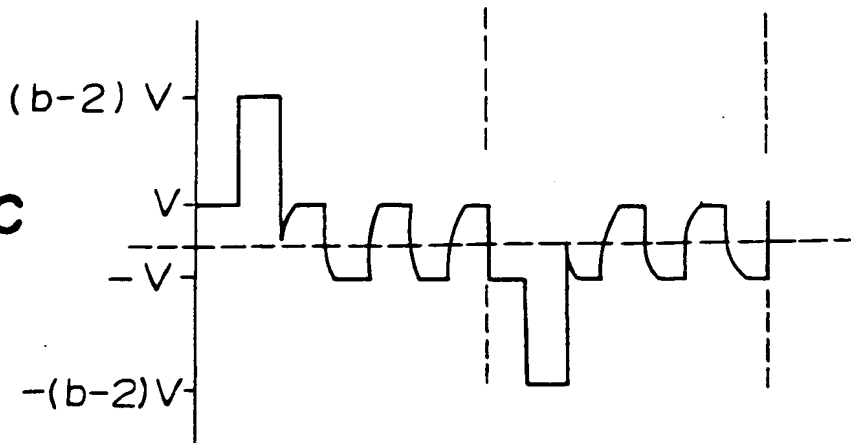


FIGURE 13A



FIGURE 13B

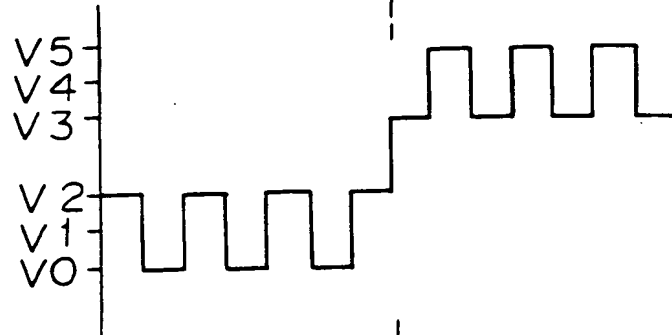


FIGURE 13C

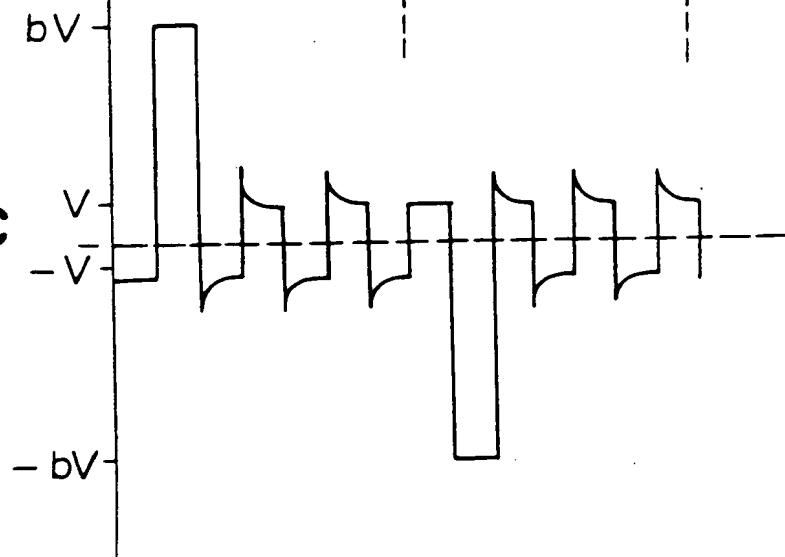


FIGURE 14

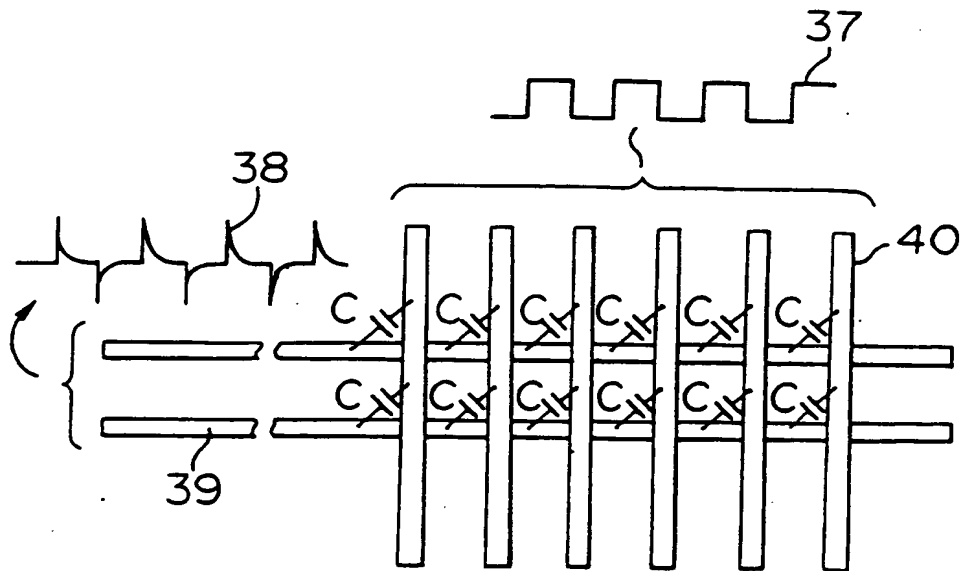


FIGURE 15

